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Final Report

Methane Fluxes from Northern Peatlands

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Research Objectives:

Natural wetlands are significant sources of atmospheric methane (CH_4). Models of $^{14}CH_4$ (Wahlen et al. 1989) and of wetland distribution and flux (Matthews and Fung 1987; Aselmann and Crutzen 1989) as well as earlier estimates (e.g. Ehhalt 1974) indicate that wetlands contribute from 19 - 27% of the estimated total emissions which is equivalent to an annual range of flux of between 30 to 300 Tg (Tg = 10^{12} g). Our initial work has shown that boreal mid-continental peatlands and wet tundra are significant sources of atmospheric CH_4 (cf. Crill et al. 1988). we have hypothesized northern wetlands to be potentially unique environments for the study of biosphere- atmosphere- climate interactions. We expect any global warming or cooling to be pronounced in northern latitudes (cf. Hansen et al. 1988) with direct effects on emissions of CH_4 and thus having direct consequences on global CH_4 and climate cycles. An understanding of the mechanisms that control and regulate CH_4 fluxes from northern wetlands is important.

From June to August 1988 we participated in the NASA ABLE-3A/BREW near Bethel, AK. Our research group collected a large data set of ground-based CH_4 flux and concentration measurements from different arctic tundra habitats. The objective of the one year of funding provided by this proposal was to support the laboratory validation of some of the field results (hence the required gc and integrator), to support the analysis of the Alaska CH_4 data set and to support the establishment of local field sites.

Summary of Results:

The laboratory analyses of our standards allowed us to adjust the results so that they are now consistent with standards used by the NOAA/GMCC global monitoring program. Intercalibration among groups analyzing trace gases is very important for future comparison of results.

The first round of data analyses were completed very successfully. The results are fully discussed in the papers and abstracts listed below and will complete the necessarily brief description provided here. The data set includes information on

CH_4 flux, CH_4 concentrations in soils, water and inside plants and the ^{13}C signature of the CH_4. Data were gathered across vegetational and moisture gradients over much of the active flux season. These data were used to study the influence of soil moisture, temperature, macrophytes and a variety of soil biogeochemical variables on CH_4 flux to the atmosphere.

Briefly, CH_4 fluxes from the tundra range from -2 to 500 mg CH_4 m^{-2} d^{-1} with the principle controls appearing to be moisture and temperature. Much lower fluxes were observed in dry upland and open water sites with higher fluxes associated with wetter sites. In the case of temperature, time averaging both the flux and the temperature decreases the noise in the data signal and greatly improves the correlation between them (cf. Bartlett et al. 1990).

The ^{13}C signature of emitted CH_4 as well as that from inside plants and in the pore waters was studied. The CH_4 emitted from the surface had a $\delta^{13}CH_4$ signature of -62.25 ± 2.23 per mil. This has direct significance to global CH_4 source budgets (cf. Chanton et al. 1990).

Internal plant gas concentrations ranged from 150 to 1200 ppm for Carex spp. and 0.2 to 4.0 % for Arctophila sp. Integrated soil CH_4 concentrations were 900 to 1200 mg CH_4 m^{-2}. Incubation studies showed high CH_4 production activity at shallow soil depths in all habitats. A large proportion (84 - 96%) of the CH_4 production could be emitted through aquatic macrophytes such as Carex or Arctophila if they are present. And up to 70% of the production may be oxidized in drier, more oxidized, regions of the soil profile (cf. Sass et al. 1990).

Surveys of possible field sites were also conducted in Maine and New Hampshire. The result was that permanent research sites were established in New Durham, New Hampshire (Angie's Bog, an Ombrotrophic peatland along the Merrymeeting River); Barrington, New Hampshire (Sallie's Fen, a minerotrophic peatland) and an upland site in Durham, NH (College Woods, a mixed hardwood environment). The ongoing research at these sites has been very successful and has engendered collaborations with research groups from the University of Florida, N.C.A.R. and other groups at the University of New Hampshire. This research started on this grant will continue with other support for the next three years at least.

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Papers and abstracts written with data the analysis of which was directly supported by this grant.

Papers:

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Sass, R.L., K.B. Bartlett, P.M. Crill, N. Dise and R.C. Harriss (1990). Methane production and distribution in an Alaskan tundra lake. J. Geophys. Res., accepted.

Chanton, J.P., C.S. Martens, C.A. Kelley, P.M. Crill and W.J. Showers (1990). Isotopic fractionation associated with methane transport by dominant emergent macrophytes of Alaskan tundra lakes. J. Geophys. Res., accepted.

Abstracts:

Crill, P.M., K.B. Bartlett, R. Sass, N. Dise and R.C. Harriss (1989). Methane flux from the tundra of the Yukon-Kuskokwim Delta. abstract. AGU Spring meeting, Baltimore.

Bartlett, K.B., P.M. Crill, R.L. Sass, N.B. Dise and R.C. Harriss (1989). Regional methane emissions from the Yukon-Kuskokwim Delta tundra. abstract. AGU Spring meeting, Baltimore.

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